

Process Specification for Radiographic Inspection

Engineering Directorate

Structural Engineering Division

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REVISIONS		
VERSION	CHANGES	DATE
Baseline	Original version	7/26/99
A	Reviewed document per QMS requirements. Updated division name, organization codes, and document numbers.	12/19/02
B	Deleted SNT-TC-1A and MSFC-STD-1249. Added NASA-STD-5009 and NASA-STD-5019. Added definition of discontinuity and indication.	2/14/07
C	Modified written procedures, special NDE qualification, and review of radiographic data	02/19/10

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REVISIONS		
VERSION	CHANGES	DATE
D	Deleted reference to SOP-009.86 from paragraph 4.0. Revised paragraph 9.0 for uniformity across all NDE PRCs.	6/29/11

1.0 SCOPE

This process specification establishes the minimum requirements for radiographic inspection of metallic and nonmetallic materials, components, and assemblies.

2.0 APPLICABILITY

This specification is applicable to in-process, final, and in-service radiographic inspections to detect cracks, porosity, voids, inclusions, improper assembly, density variations, corrosion, and other discontinuities.

3.0 USAGE

This specification shall be invoked by including an inspection note on the applicable engineering drawing or by reference in a Process Specification, Task Performance Sheet, Discrepancy Report/Material Review Record, or other appropriate document. The engineering drawing or referencing document shall specify the criteria by which components are judged acceptable. An example of acceptance criteria for welded components are contained in NAS 1514. When there are different acceptance criteria for different areas on a component, the drawing shall be zoned with the acceptance criteria identified for each zone. If the number of components to be inspected and the amount of coverage of each component are not specified, all components shall be examined and shall receive 100 percent radiographic coverage.

A typical radiographic inspection note for welded flight hardware is given in Figure 1.

**PERFORM RADIOGRAPHIC INSPECTION OF WELDS PER
JSC PRC-6503, ACCEPTANCE CRITERIA PER NAS 1514,
CLASS I.**

Figure 1.

3.1 INSPECTION SEQUENCE

The stage in the manufacturing process where radiographic inspection is performed should be specified on the engineering drawing or in the referencing document. Factors to be considered when specifying the inspection sequence are: the accessibility of both sides of the component; the complexity of the assembly as it relates to optimal alignment of the radiation beam; loading of the component or assembly (compressive loads reduce cracks detectability); and the need for subsequent manufacturing processes that could generate

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discontinuities. Radiographic inspection may be performed before heat treatment, provided liquid penetrant or magnetic particle inspections are performed after heat treatment.

3.2 SPECIAL NDE OF FRACTURE CRITICAL COMPONENTS

When implementation of fracture control requirements necessitates Special Nondestructive Evaluation (NDE) of a fracture critical component, the requirement for Special NDE shall appear in the inspection note as shown in Figure 2. When Special NDE is required, the specific inspection procedure and inspector shall be qualified in accordance with Section 7.0.

**PERFORM RADIOGRAPHIC INSPECTION OF WELDS PER
JSC PRC-6503, ACCEPTANCE CRITERIA PER NAS 1514,
CLASS I. SPECIAL NDE QUALIFICATION REQUIRED.**

Figure 2.

4.0 REFERENCES

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. All documents listed are assumed to be the current revision unless a specific revision is listed. In the case of conflict between this specification and the technical requirements cited in other referenced documents, the requirements of this document take precedence.

ASTM E 1742	<i>Standard Practice for Radiographic Examination</i>
NASA-STD-5009	Nondestructive Evaluation Requirements for Fracture Critical Metallic Components
NAS 410	<i>NAS Certification & Qualification of Nondestructive Test Personnel</i>
SNT-TC-1A	<i>Personnel Qualification and Certification in Nondestructive Testing</i>
NAS 1514	<i>Radiographic Standard for Classification of Fusion Weld Discontinuities</i>
NASA-STD-5003	<i>Fracture Control Requirements for Payloads Using the Space Shuttle</i>

NASA-STD-5019 *Fracture Control Requirements for Spaceflight Hardware*

SSP 30558 *Fracture Control Requirements for Space Station*

The following references were used to develop this process specification:

SOP-007.1 *Preparation and Revision of Process Specifications (PRC's)*

JSC 8500 *Engineering Drawing System Requirements*

5.0 MATERIAL REQUIREMENTS

Film, non-film recording media, and film processing solutions shall be in accordance with ASTM E 1742.

6.0 PROCESS REQUIREMENTS

6.1 GENERAL

Radiographic inspections shall be performed in accordance with ASTM E 1742 except as modified by this specification.

6.2 WRITTEN PROCEDURES

A specific written procedure or a general written procedure with a written part specific technique shall be prepared for each part to be inspected. The procedures shall meet the requirements of this specification and shall ensure the consistency and reproducibility of the inspection at the required radiographic quality level. General procedures covering a variety of different parts may be used provided they meet the requirements of this specification and clearly apply to the parts to be inspected. At a minimum, the part specific procedure or the general procedure and part specific technique shall cover all of the information required by ASTM E 1742.

For work performed at JSC facilities, specific or general written procedures should consist of Detailed Process Instructions (DPIs) selected for use from the DPI-6503-XX series of work instructions.

6.3 FILM DENSITY

Film density in the area of interest shall be in the range from 2.0 to 4.0 (inclusive). Film densities greater than 4.0 are permitted when approved by the JSC Materials and Processes Branch (ES4). Densities less than 2.0 are permitted only when items not requiring an image quality indicator (IQI) are inspected.

6.4 APPLICABLE AREA

For components requiring an IQI, only the area of the film that falls within a 10 degree cone of radiation (10 degree total solid angle, apex at the radiation source, central axis of the cone equal to the central axis of the radiation beam) shall be considered valid for interpretation.

6.5 SOURCE-TO-FILM DISTANCE

The minimum allowable source-to-film distance for flight hardware shall be calculated using a maximum geometric unsharpness (U_g) of 0.003 inch.

6.6 FRACTURE CRITICAL COMPONENTS

Radiographic inspections of fracture critical components shall be performed in accordance with the process requirements in NASA-STD-5009. The requirements in NASA-STD-5009 not otherwise covered in this specification are included in the following:

- a. The Radiographic Quality Level shall be at least Level 1 (2 - 1T);
- b. Film density in the area of interest shall be in the range from 2.5 to 4.0 (inclusive);
- c. Only the area of the film that falls within a 5 degree cone of radiation (5 degree total solid angle, apex at the radiation source, central axis of the cone equal to the central axis of the radiation beam) shall be considered valid for interpretation;
- d. Potential crack-like flaws shall be oriented in the plane of radiation;
- e. Components shall be of consistent thickness; and
- f. Film shall be placed in close contact with the component.

When Special NDE is specified by the engineering drawing or referencing document, the inspection procedure and inspector shall be qualified in accordance with Section 7.0.

7.0 SPECIAL NDE QUALIFICATION

Use of Special NDE in accordance with NASA-STD-5009, NASA-STD-5019, NASA-STD-5003 or SSP 30558 requires formal demonstration of NDE reliability to at least 90/95 to detect flaws of a specific size given in the intended acceptance criteria. The radiography crack detectability size is given as the depth of the crack as a fraction of the part thickness. The crack plane is assumed to be oriented approximately normal to the part surface. The special radiography crack size is frequently chosen to be 0.6 times the part thickness. . Each procedure, procedure application, and operator must demonstrate the required capability. Requests for Special NDE qualification shall be directed to the JSC Materials and Processes Branch (ES4).

8.0 DEVIATIONS AND WAIVERS

Any deviations or waivers regarding the use of this process specification shall be requested in writing. This request shall be directed to the JSC Materials and Processes Branch (ES4) with the appropriate justification and rationale. A written response will be provided upon such a request.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

Personnel performing acceptance inspections of Class I, II, IIW and GSE hardware shall be qualified and certified, at a minimum, to Level 2 in accordance with NAS 410. Personnel performing acceptance inspections requiring Special NDE shall also be qualified and certified for Special NDE in accordance with NASA-STD-5009.

Personnel performing acceptance inspections of Class III, STE/D, mockup, and facility hardware shall be qualified and certified in accordance with either NAS 410 or SNT-TC-1A. Personnel making accept/reject decisions shall, at a minimum, be certified to Level 2. Level 3 personnel making accept/reject decisions shall have successfully completed a hands-on practical examination equivalent to the examination required for Level 2. Level 1 personnel may perform acceptance inspections under the direct supervision of a Level 2 but shall not make accept/reject decisions.

Formal qualification and certification is not required for personnel performing engineering evaluation inspections.

10.0 REVIEW OF RADIOGRAPHIC DATA

Radiographic inspection report and image identification data of criticality 1 hardware shall be reviewed for accuracy by a minimum of two personnel, one of

the persons shall be a radiographic inspector gathering the data and the other person shall be a cognizant engineer. Both persons shall sign on the inspection report acknowledging the review of the data.

11.0 **DEFINITIONS**

90/95	The point where the 95% lower confidence bound on the Probability of Detection (POD) vs. flaw size curve crosses 90% POD or 90% POD with 95% lower confidence bound.
Final Inspection	The final inspection performed for the acceptance of the component.
Fracture Critical Component	Classification which assumes that fracture or failure of the component resulting from the occurrence of a crack will result in a catastrophic hazard. Fracture critical components will be identified as such on the engineering drawing.
In-Process	Inspections that occur during manufacturing before a component is in final form.
In-Service	Inspections performed on components that are in use or storage.
Special NDE	A fracture control term denoting nondestructive inspection process (that specifies personnel, procedures, and equipment) with a demonstrated capability to reliably (90/95) detect a specified flaw size that is smaller than those normally detected by the Standard NDE procedures.
Discontinuity	An intentional or unintentional interruption in the physical structure or configuration of a material or component that may be detectable by nondestructive testing; a flaw. Discontinuities are not necessarily rejectable.
Indication	Evidence of a discontinuity that requires interpretation to determine its significance.